

Validation of On-Orbit Methodology for the Assessment of Cardiac Function and Changes in the Circulating Volume Using Ultrasound and Braslet-M Occlusion Cuffs

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Introduction:

The objective of this joint U.S. - Russian project was the development and validation of an in-flight methodology to assess a number of cardiac and vascular parameters associated with circulating volume and its manipulation in long-duration space flight. Responses to modified Valsalva and Mueller maneuvers were measured by cardiac and vascular ultrasound (US) before, during, and after temporary volume reduction by means of Braslet-M thigh occlusion cuffs (Russia).

Materials and Methods:

The study protocol was conducted in 14 sessions on 9 ISS crewmembers, with an average exposure to microgravity of 122 days. Baseline cardiovascular measurements were taken by echocardiography in multiple modes (including tissue Doppler of both ventricles) and femoral and jugular vein imaging on the International Space Station (ISS). The Braslet devices were then applied and measurements were repeated after >10 minutes. The cuffs were then released and the hemodynamic recovery process was monitored. Modified Valsalva and Mueller maneuvers were used throughout the protocol. All US data were acquired by the HDI-5000 ultrasound system aboard the ISS (ATL/Philips, USA) during remotely guided sessions. The study protocol, including the use of Braslet-M for this purpose, was approved by the ISS Human Research Multilateral Review Board (HRMRB).

Results:

The effects of fluid sequestration on a number of echocardiographic and vascular parameters were readily detectable by in-flight US, as were responses to respiratory maneuvers. The overall

volume status assessment methodology appears to be valid and practical, with a decrease in left heart lateral E' (tissue Doppler) as one of the most reliable measures. Increase in the femoral vein cross-sectional areas was consistently observed with Braslet application. Other significant differences and trends within the extensive cardiovascular data were also observed. (Decreased - RV and LV preload indices, Cardiac Output, LV E' all maneuvers, LV Stroke Volume).

Conclusions:

This Study:

- 1) Addressed specific aspects of operational space medicine and space physiology, including assessment of circulating volume disturbances
- 2) Expanded the applications of diagnostic ultrasound imaging and Doppler techniques in microgravity.
- 3) Used respiratory maneuvers against the background of acute circulating volume manipulations which appear to enhance our ability to noninvasively detect volume-dependency in a number of cardiac and vascular parameters.
- 4) Determined that Tei index is not clinically changed therefore contractility not altered in the face of reduced preload.
- 5) Determined that increased Femoral Vein Area indicating blood being sequestered in lower extremities correlates with reduced preload and cardiac output.
- 6) That Braslet may be the only feasible means of acutely treating high pressure pulmonary edema in reduced gravity environments.